

Principal Research Results

Electro-chemical Reduction of UO_2 Fuel and MOX Fuel

Background

Spent MOX fuel and spent high burn-up fuel are expected to be generated and, therefore, reprocessing technologies for these spent fuels are required in the near future. Also, discussion on fuel-cycle technologies to introduce fast reactors will be started after the operation of Rokkasho reprocessing plant begins. It will take at least several decades to replace all present light water reactors with fast reactors. Thus, flexibilities to correspond to the change of social needs will be one of the most important factors for the fuel-cycle technologies during the replacement period. An electro-chemical reduction process has various characteristics suitable for the replacement period. (i) Low capital and running costs even in a small size plant. (ii) High ability to treat various kinds of spent fuels without major changes of process. (iii) High performance to resist nuclear proliferation.

Objectives

The aim of present study is to show the validity of the electro-chemical reduction process based on the experimental studies using 100g-scale of UO_2 -fuel and 200mg-scale of MOX.

Principal Results

1. Electro-chemical reduction of UO_2 fuel

Fig.1 shows a schematic image of test cell and a picture of UO_2 fuel set on the Ti-cathode. Following results are obtained: (i) In LiCl solvent system, UO_2 fuel was completely reduced to U metal with 53% of current efficiency. Fig.2 shows the cross section of metal product. (ii) In CaCl_2 solvent system, UO_2 fuel was not completely reduced in the present test because the current efficiency was maintained at around 25%. However, the morphology of the product as given in Fig.3 showed that UO_2 fuel would be completely reduced if the operation continued. (iii) The morphology of the product was affected by the type of molten salt solvent, and the particle size and density of initial UO_2 , as shown in Fig. 4. The adjustment of the product morphology could accelerate the process speed to be suitable for the industrial process.

2. Electro-chemical reduction of MOX fuel

In the MOX tests, (i) Both in LiCl and CaCl_2 solvent systems, MOX fuel containing Pu was completely reduced to metal. (ii) At the interface between the reduced and non-reduced regions, both regions formed a layer and a network structure in UO_2 fuel and in MOX fuel, respectively, as shown in Fig.5. Since the network structure could supply larger reaction area, the reduction of MOX fuel easily occurred in comparison to UO_2 fuel.

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Future Developments

Since the particle size and density of fuel is one of the most important parameters to control the process, optimization will be carried out. Also, the investigation of fuel-cycle scenario using the electro-chemical reduction process will be materialized.

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Reference

M. Kurata et al., 2004, "Electrochemical reduction of MOX in LiCl", J. Nucl. Mater. vol.328, PP.97-102.



100g of UO₂ on cathode.

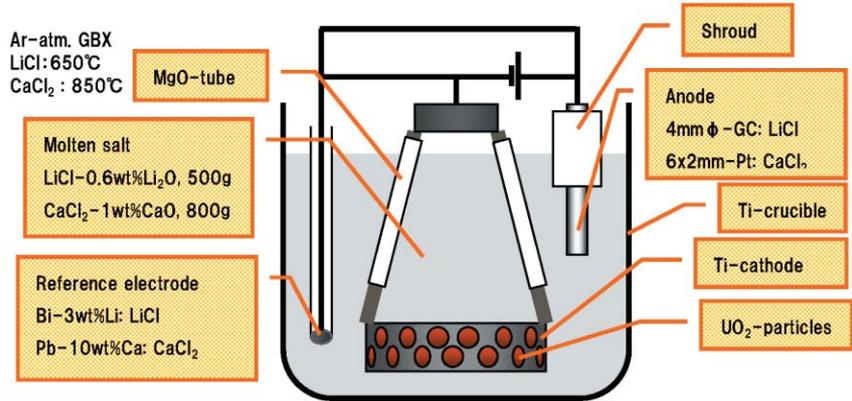


Fig.1 Image of test cell.

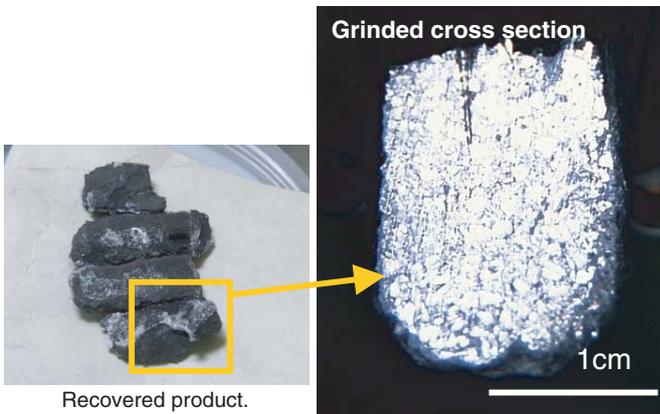


Fig.2 Reduction product obtained in electro-chemical reduction test in LiCl. (Grinded cross section shows metallic-shine.)

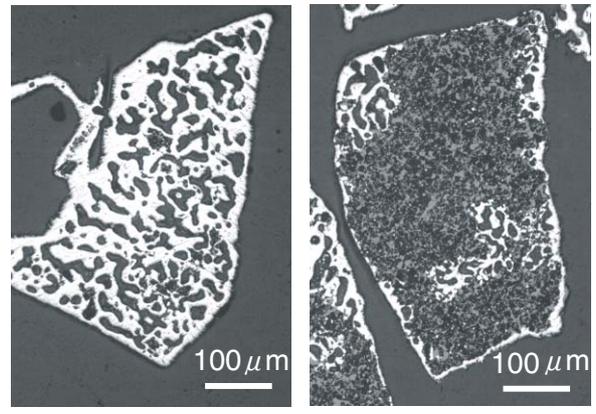


Fig.3 Various reduced UO₂-particles obtained in electro-chemical reduction test in CaCl₂. (White part : U-metal, grey part : U-oxide)

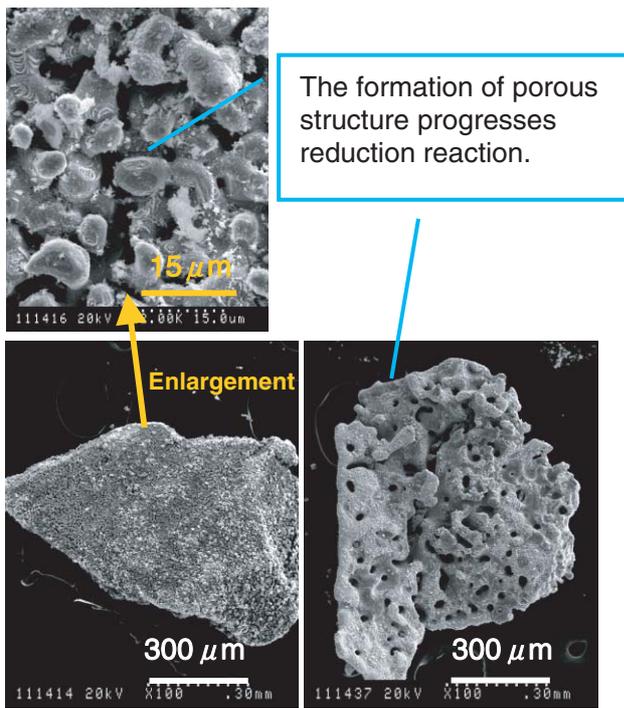


Fig.4 Difference in eduction products obtained in LiCl and CaCl₂ systems.

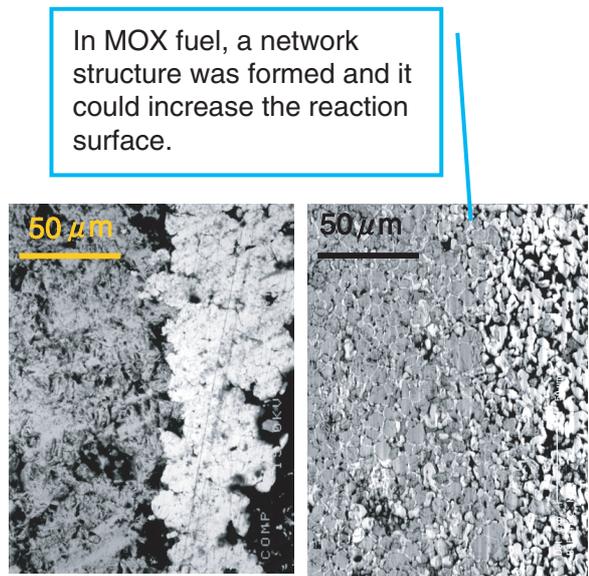


Fig.5 Interface between reduced (right) / non-reduced (left) regions